Comparison of the expanded breeding population survey results with those of the NAWBPS and development of an improved survey design will be covered in a future report.

STUDY AREA

The Yukon Delta National Wildlife Refuge is located in southwest Alaska adjacent to the Bering Sea (Fig. 1). YDNWR extends about 400 km north to south and about 300 km east to west and occupies about 106,400 km^2. A volcanic mountain range occurs on the northeastern and southeastern portions of YDNWR but the predominant physical feature is the vast series of historic deltas of the Yukon and Kuskokwim rivers. The delta contains countless water bodies of all sizes. Lakes thaw in May and begin to freeze in October whereas rivers break-up in May but generally do not freeze till November.

Three climatic zones are present. The maritime zone, with moderate temperatures and high precipitation, includes the coast and islands. The continental zone occupies the interior portion of YDNWR and has more extreme temperatures and less precipitation. The transition zone occurs between the other two and has characteristics of each.

YDNWR occupies the northern boreal subzone of southwestern Alaska and consists predominantly of subarctic tundra underlain by permafrost (U.S. Fish and Wildlife Service 1988). In addition to permafrost, periodic flooding by tidal or riverine water and wind are the major forces influencing vegetation communities. Graminoid plant complexes are, in part, created by periodic flooding. Three characteristic wetland types that occur in the coastal zone were described by Handel and Gill (1986): sedge meadows, graminoid meadows and dwarf shrub tundra. Sedge and graminoid meadows support the highest numbers of waterfowl on YDNWR (Lensink and Rothe 1986).

Yukon-Kuskokwim delta waterbirds, particularly geese, are important components of the subsistence food base of Alaska Natives (Wolfe 1981). Approximately 27% of the land in YDNWR is privately owned, predominantly by Native village and regional corporations and the State of Alaska (Fig. 2). This privately owned land is occupied primarily by Alaska Natives, many of whom continue to practice a hunting, fishing and gathering (subsistence) lifestyle.

For further information on the study area see Kincheloe and Stehn (1991), Tande and Jennings (1986) and Thorsteinson et al. (1989).

METHODS

Aerial Survey Technique

The traditional NAWBPS transects are shown in Figure 3. For the expanded breeding population survey, we used a True Basic program and ARC/INFO to generate systematically spaced transects from a random coordinate. Transects were oriented east-west along lines of latitude and totaled 11,309 km (Fig. 4). Systematic sampling was appropriate for the dual objectives of mapping distributions and estimating total numbers when accuracy of the estimate's standard error was not critical (Caughley 1977). We eliminated portions of transects over non-wetland habitat, divided transects into 14.8 km segments and plotted transects and segments on 1:250,000 scale topographic maps for use in the aircraft.

Because time was insufficient to fly all transects in one year, a pilot and observer flew a different set of transects each year. Total length of transects flown annually was about 2,300 km. Distance between transects was about 30 km each year. When the 4 sets of transects were combined for distribution mapping, spacing between transects was about 7.4 km. Each year the transects sampled about 920 km^2 of the 72,117 km^2 survey area.

Survey methods followed the conventions established for breeding ground surveys in North America (USFWS and CWS 1987). Surveys coincided with egg-laying or early incubation stages of breeding waterfowl. Survey dates were as follows: 10-13 June, 1989; 6-15 June, 1990; 6-11 June, 1991; and 11-17 June, 1992. Aircraft were flown at 137 to 153 km hr^{-1}, 30 to 46 m of altitude, with wind speed < 24 km hr^{-1}, with ceilings > 152 m and with visibility > 16 km. The pilot used a Loran C or global positioning system and the survey maps to maintain a precise course while flying transects.

The pilot and observer recorded transect numbers, segment numbers, segment start and stop points, direction of flight and bird observations on continuously running cassette tapes. Birds observed in a 200-m strip on each side of the aircraft were identified to species and categorized as a single, pair, or flock. For ducks, only males were identified and counted.

Geographic coordinates of each observed bird were captured using a technique developed by Butler et al. (in prep A). Tapes were replayed and data were entered into a computer in real time using a True BASIC program. Distances along segments to observations were automatically calculated by the computer based on elapsed time to an observation in proportion to elapsed time to fly the segment and using known segment length. These observation distances were then converted to geographic coordinates using another True BASIC program.

Population indices

We calculated densities, population indices and variability for each species and each year using ratio estimate procedures described by Cochran (1977). Mean 4-year indices were also calculated from pooled 1989-1992 data to determine the relative importance of particular species and species groups to the refuge avifauna. Indices were based on indicated total birds: $2*(S+P)+F$ where S = number of single birds observed, P = number of bird pairs observed, and F = number of birds in flocks. For ducks, the assumption was that a single male represented a breeding pair of which the hen was on a nest and not easily observable. Single male ducks were doubled for all duck species except redhead, scaup and ring-necked duck. Single observations of other waterbird species (geese, swans, cranes, grebes and loons) were not doubled. Numbers of ducks were corrected for visibility bias using correction factors from Conant and Groves (1992) (Table 1). Numbers for other waterbird species were not corrected for visibility bias.

Variance of population indices was based on the variation among sampling units defined as entire transects. Segments were not used in calculation of variance nor was any stratification employed in the analysis. The additional variance associated with visibility correction factors was not calculated. Population indices for indicated total birds corrected for visibility bias were plotted with trend lines indicated by linear regression.

We divided transects by land ownership and calculated densities on federal versus non-federal land for the 1992 survey.

Waterbird Distribution

We produced waterbird density distribution maps from combined 1989-1992 data using a technique developed by Butler et al. (in prep B). Geographic coordinates of observed birds were calculated in True BASIC by combining transect position and length files with bird observation files. Another True BASIC program calculated bird density in blocks of specified area at specified regular intervals along each transect. The resulting location and density data were input into PC TIN, a 3-dimensional terrain modelling software package. Isopleth maps of waterbird density for major species and species groups were generated. Density values were based on indicated total birds uncorrected for visibility bias.

We used duck density maps to calculate amount and percentage of land area in each density class for combined duck species on federal versus non-federal land.

RESULTS

Population indices

Trends of population indices from 1989-1992 are presented in Appendix 1. Of the major species, northern pintail, scaup, green-winged teal and northern shoveler population indices increased whereas black scoters decreased. Coefficients of variation for northern pintails and scaup ranged from 10-14% and 8-16%, respectively. Variability was much higher for other species.

Relative importance by species and species groups

Four-year average population indices were about 1 million ducks, 100,000 geese, and 40,000 loons (Tables 2-5). Mean density for northern pintails was about 5/km^2 and scaup about 3/km^2 (Table 6). Total duck densities averaged 15/km^2 (1989-1992) on YDNWR. Northern pintails were the most abundant ducks in all years averaging over 300,000 birds. They accounted for about 31% of all ducks observed and 17% of the North American continental pintail population index (Caithamer et al. 1992). The species composition of the remainder of the duck population was: 18% scaup, 13% green-winged teal, 9% northern shoveler, 8% black scoter, 7% American wigeon, 6% mallard, 3% oldsquaw, and 1% goldeneye. The goose population was comprised of 52% Canada geese (with cackling Canada geese and Taverner's Canada geese subspecies combined), 25% white-fronted geese, 20% emperor geese, and 3% brant.

Relative importance by land ownership

Densities for pintails, shovelers, scaup and combined duck species were higher on non-federal lands (Table 7). Densities of other species on non-federal lands were about equal to or less than densities on federal land.

Waterfowl Distribution

We obtained over 17,000 geographic locations of birds during the 4 years of the survey. We created point location maps (Fig. 5) and density isopleth maps for individual species and species groups to display the relative abundance and distribution of waterbirds on YDNWR (Fig. 6 and Appendices 2-21). Density values were based on number of indicated total birds uncorrected for visibility bias. Figures 7-9 show density distributions for dabbling ducks, diving ducks and sea ducks, respectively.

The percentage of land area in each density class for combined duck species was about equal between federal versus non-federal land (Fig. 10 and Table 8).

DISCUSSION

Population indices

Annual population indices for abundant species such as northern pintails and scaup were less variable than those for scarcer species. Annual coefficients of variation for northern pintails and scaup were < 15% resulting in relatively more precise linear regression trends for these species. Observers were not constant throughout the survey, likely accounting for some of the variability of the indices. The surveys yielded highly variable population indices for species such as green-winged teal, spectacled eiders and brant for different reasons. Green-winged teal, due to small size and cryptic coloration, were difficult for less experienced observers to detect. Brant population indices were well below breeding population levels estimated by other methods (Sedinger et al. in press). Systematic transects spaced at 30 km intervals missed brant colonies in all years except 1992 (Tables 2-5) and failed to sample important spectacled eider habitat on Kigigak Island. Thus, linear regression trends based on only 4 annual indices with large sampling errors should be interpreted cautiously.

The coastal zone survey provided better indices for brant, cackling Canada geese and emperor geese since these species are exclusively coastal and the survey is more intensive (transects spaced at 1.6 km intervals) in that area. The most precise indices for white-fronted geese and Canada geese (cacklers and Taverner's combined) could probably be attained by combining coastal zone survey data with expanded survey data in the interior of YDNWR.

Similar systematic aerial surveys have been flown on the Yukon Flats and the arctic coastal plain of Alaska allowing comparisons of waterfowl densities between these areas. Densities of certain species on YDNWR were generally lower than on the Yukon Flats duck production stratum (Platte and Butler 1992) but higher than those on the arctic coastal plain of Alaska (Brackney and King 1992) (Table 9). Water bodies on the Yukon Delta and the arctic coastal plain of Alaska are likely less fertile or productive, partially due to cooler temperatures, than those on the Yukon Flats, accounting for some of the differences in duck density (Lensink and Rothe 1986). Although duck density was higher on Yukon Flats, the total average population size of ducks was over 1,000,000 on the larger Yukon Delta compared to 824,000 on the arctic coastal plain of Alaska and 460,000 on Yukon Flats.

Non-federal lands in YDNWR contained higher densities for some species perhaps reflecting the presence of higher quality habitat. Although densities were higher for pintails, shovelers, scaup, and combined duck species, non-federal land comprised about one-third of the acreage of YDNWR. Therefore, population size for these species was smaller on non-federal land than on federal land.